



Environmental Remediation Group

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**SENT VIA EMAIL**

Memorandum

Date: December 21, 2018

Subject: Response to USEPA Memo dated Nov. 29, 2018 – Resolution of CSM

To: USEPA Case Team

From: Olin Case Team

Olin has received and reviewed USEPA's memorandum dated November 29, 2018 and titled *"Improving Resolution and Technical Basis for CSM Relative to Main Street and Jewel Drive DAPL Pools, Olin Chemical Superfund Site (OCSS or Site), Wilmington, MA."* While Olin believes that there are data gaps that need to be addressed to refine an ultimate remedial design, we are in general agreement that an Interim Action Feasibility Study (IAFS) can be generated without further data gap-related investigation with one important exception. With this one exception notwithstanding, Olin believes that agreement to proceed with an IAFS without the need to pursue further data gaps is a positive outcome of the October and December 2018 meeting that will enable material progress on the OCSS project.

The exception noted above concerns the containment area. We do believe that additional work is required to finalize a remedial strategy relative to DAPL and diffuse groundwater within the Containment Area. USEPA's referenced memo does not attempt to address resolution of the containment area CSM, and as such, Olin's response focuses solely on comments made by USEPA relative to the Main Street and Jewel Drive DAPL areas in its November 29<sup>th</sup> memo and USEPA's presentation on December 10. We look forward to discussion the containment area CSM during the upcoming meeting with the USEPA technical team in January 2019.

In their memo, USEPA questions the accuracy of the long-standing CSM developed over many years for the Site. USEPA's questions are based on assertions regarding the density of data used to develop the current CSM, and more importantly, the accuracy of the data itself. Olin has provided USEPA with all the data that exists and used to ascertain the geometry of the bedrock surface at the Site. However, USEPA's initial interpretation of the bedrock surface was not based upon all available relevant data. USEPA's initial review did not question the accuracy

of the data, but rather concluded that the Main Street bedrock saddle does not exist and that a “spillway” must be present that would allow DAPL to continue to flow gravimetrically across the Site. Olin pointed out, during a meeting on October 25, 2018, that a critical seismic line was missing from USEPA’s interpretation. Olin has also pointed to other bedrock elevation control points and actual data collected from surrounding wells to demonstrate that the existence of a spillway is a poorly conceived conclusion. We believe that these data, considered together, provide a reliable CSM pending closure of a few data gaps that are likely required for verification. Olin agrees that limited additional data can and should be collected to prove the CSM more definitively. Olin does not agree that significant time and money should be spent in an academic pursuit to define every nook and cranny of the bedrock surface, but should focus efforts on developing data that both Olin and USEPA need to define the nature of practicable remedial efforts at the Site, both in the near and longer terms.

USEPA has pointed out several data gaps over the course of recent discussions. We agree that the bedrock surface in the immediate vicinity of what Olin considers to be the Main Street DAPL pool should be verified. Verification should be aimed at providing both the USEPA and Olin case teams with data necessary to develop a more robust remedial investigation report as well as design an appropriate remedy adequately. Olin believes that a small number of monitoring wells and/or bedrock borings (including at least one multi-port monitoring well) is sufficient to fill the identified data gaps. A more detailed plan to proceed will be developed in concert with the USEPA case team.

Olin provides response to USEPA’s comments below. Each USEPA comment is listed followed by response (in italic font). In some cases, responses are provided per paragraph in USEPA’s original comments for the sake of context.

**USEPA General Comment #1:** General CSM Data Quality Issues: The comments below further address the following issues as they relate to the larger CSM relative to DAPL and highly contaminated groundwater fate and transport, particularly in relation to the bedrock. While the following data collection methods are generally acceptable, the claimed precision and over extrapolation of the results is of concern.

- General Issues regarding adequacy of data density, spatial resolution and temporal variability
- Uncertainty regarding estimated DAPL pool elevations and thickness
  - Conductivity Methods for DAPL estimation – Measurement Accuracy, Precision, and other Issues
  - Induction Methods for DAPL estimation – Measurement Accuracy, Precision, and other Issues
  - Direction Sampling of DAPL from multiport wells – Measurement Accuracy, Precision, and other Issues

- Lateral and Vertical Resolution regarding top-of-rock estimations by a variety of methods and resulting uncertainties
  - Soil Borings and Conventional Drilling Methods
  - Direct Push Methods
  - Rotosonic Drilling
  - Seismic Reflection
  - Seismic Refraction
- Temporal Variability of Various CSM elements vs. Measurement Frequency

***Olin Response #1:*** *Olin has made no representation regarding specific precision of the measurements referenced above, but believes the precision of data collected to date is adequate for its intended purpose and is corroborated appropriately. This memo is the first time any representation has been made by USEPA regarding this issue, and Olin contests the validity of USEPA's claims in this regard for reasons specified below. Also, Olin disagrees with USEPA's characterization that there has been "over extrapolation of the results." To the contrary, over the 20+-year history of this project, Olin has attempted to provide a fair and reasonable interpretation of the data based on fact, sound science, and best professional judgement and the ongoing data collection continues to corroborate Olin's CSM.*

*In addition, with over twenty years of groundwater monitoring data at a large number of locations, the OCSS has a larger temporal data set than many under CERCLA. It is not the purpose of remedial investigations to evaluate temporal variability in the data set, but rather to evaluate if current data indicates whether an unacceptable risk is posed by the site.*

**USEPA General Comment #2:** Spatial resolution (general): A common problem to many of the central elements of Olin's CSM regards the lack of spatial resolution inherent to much of the Site data set. Overreliance on spatially limited data can result in significant errors. A CSM which combines and compounds such errors may ultimately diverge from reality in substantial and significant ways. For example, under most circumstances, data collected from a single bedrock location should not be used to speculate what conditions may exist hundreds of feet away at a different location. Such speculation would be risky at a "simple site", let alone a complex site such as OCSS. The degree of spatial resolution must also be commensurate with the complexity of the Site's subsurface. These issues reach critical importance regarding bedrock characterization, interpretation, and CSM development at OCSS due to the degree of folding and faulting and overall complexity of the Site. This issue is discussed further in context, in the comments below, regarding specific technical issues.

***Olin Response to USEPA General Comment #2:*** *Olin believes that when all relevant data is considered, that the CSM is well-defined, especially in the vicinity of Main Street. For example, the USEPA has ignored seismic line Law 5 even though bores generally corroborate the seismic reflectance TOR elevations. Similarly, USEPA appears to have ignored the direct push data presented on Figure 3.2-6 in the Draft OU3 RI. Finally, it's important for USEPA to realize that*

*the lowest elevation of the Main Street saddle is to the north in the vicinity of SB-8/MP-4. Olin has always represented this area as a location where diffuse groundwater may overtop the saddle. This interpretation is corroborated by downgradient monitoring well GW-58D which has characteristics of diffuse layer, not DAPL, consistent with Olin's CSM. These data repudiate the USEPA CSM, which would have DAPL flowing over the top of the saddle. Note, GW-58D data is included in the draft RI report that was submitted to USEPA in March 2018 and is attached hereto as Attachment A.*

**USEPA General Comment #3 (1<sup>st</sup> paragraph):** Spatial resolutions and CSMs: The issue of spatial resolution - and the adequacy thereof to support a CSM – is critical and preeminent when evaluating bedrock conditions beneath the Main Street area, or for that matter any portion of the OCSS subsurface. It must be acknowledged that the area affected by the OCSS is immense. In most areas at OCSS, the density of characterization data (borings, seismic, etc.) is arguably weak, particularly in bedrock. For instance, Olin often makes comparisons, inferences, and draws conclusions by comparing conditions from wells in the Main Street area with “downgradient wells”. In bedrock, the nearest down-gradient well to the Main Street area is on the order of the length of one or more football stadiums away, i.e., many hundreds of feet. This is an inappropriately far distance for direct comparison, even in areas with simple geologic conditions. As such, elements of the CSM which rely on trend comparisons, or other comparative means to draw conclusions or inferences relative to the two areas are “fuzzy” at best, and at worst incorrect or misleading. This issue is a specific example of the types of general assertions and assumptions which pervade Olin's CSM, and often do not have any substantive data to support them. The reality may be much different.

**Olin Response USEPA General Comment #3 (1<sup>st</sup> Paragraph):** *The USEPA is incorrect that, “the nearest down-gradient well to the Main Street area is on the order of the length of one or more football stadiums away, i.e., many hundreds of feet.” In actuality MP-4 (SB-8 on **Figure A**) has multiple ports completed in bedrock and is only ~50 ft west of Main Street. As a larger issue, bedrock is not the major pathway from a mass flux perspective because it is less transmissive than the deep overburden.*

*In addition, there have been 20+ years of OCSS investigation and groundwater monitoring which allows reasonable conclusions to be drawn. Oriented bedrock fracture data from across the Site indicate that the bedrock aquifer is sufficiently cross-connected by northeasterly and northwesterly striking fractures, as well as other joint orientations at the Site scale to allow groundwater to flow in bedrock in accordance with prevailing hydraulic gradients. We do not believe these conclusions are over-reaching. Conceptualization of the bedrock system as an anisotropic equivalent porous medium at the Site scale is an appropriate conceptual and numerical conclusion: Groundwater levels and quality data collected to-date corroborate this conceptualization.*

**USEPA General Comment #3 (2<sup>nd</sup> Paragraph):** The purpose of this discussion is not only to point out the general pitfalls of “over projecting” assumed conditions over huge lateral and

vertical distances, but also to point out that it is premature to propose a particular sampling strategy - based on the existing well network - which can elucidate the veracity of the current CSM in the Main Street area regarding DAPL pool elevations, bedrock elevations, and linkages to conditions measured in downgradient groundwater. USEPA has stated in previous comments that the downgradient monitoring network relative to the Main Street area is deficient, and in need of augmentation, particularly with respect to bedrock. As a first step, a more resolved depiction of the TOR surface in the Main Street area is needed as well as the elevations, and thicknesses, and lateral extent of all DAPL pools in this area. This is not a trivial undertaking, but such information is needed to inform subsequent efforts to augment the existing well network in key locations and depths “downgradient” of key areas of DAPL accumulation or other contaminant “hot spots” in the Main Street area.

***Olin Response to USEPA General Comment #3 (2<sup>nd</sup> Paragraph)*** *The down gradient monitoring well network within the MMB area adequately defines both the lateral extent of impacted groundwater and the core of the plume of impacted groundwater. This delineation meets the current required elements to develop a groundwater risk assessment. USEPA has also indicated it believes the data is generally sufficient for a groundwater Feasibility Study, although USEPA and Olin seek additional comprehensive data to augment the existing data set collected for OU3 and to better understand current Site conditions. If the immediate goal for the project is source control (i.e., the DAPL pools), any additional data collected should be done so with this objective in mind. Olin agrees that there are some areas in the Main Street area where additional TOR data would help to refine the existing CSM of the bedrock saddle and pool elevation.*

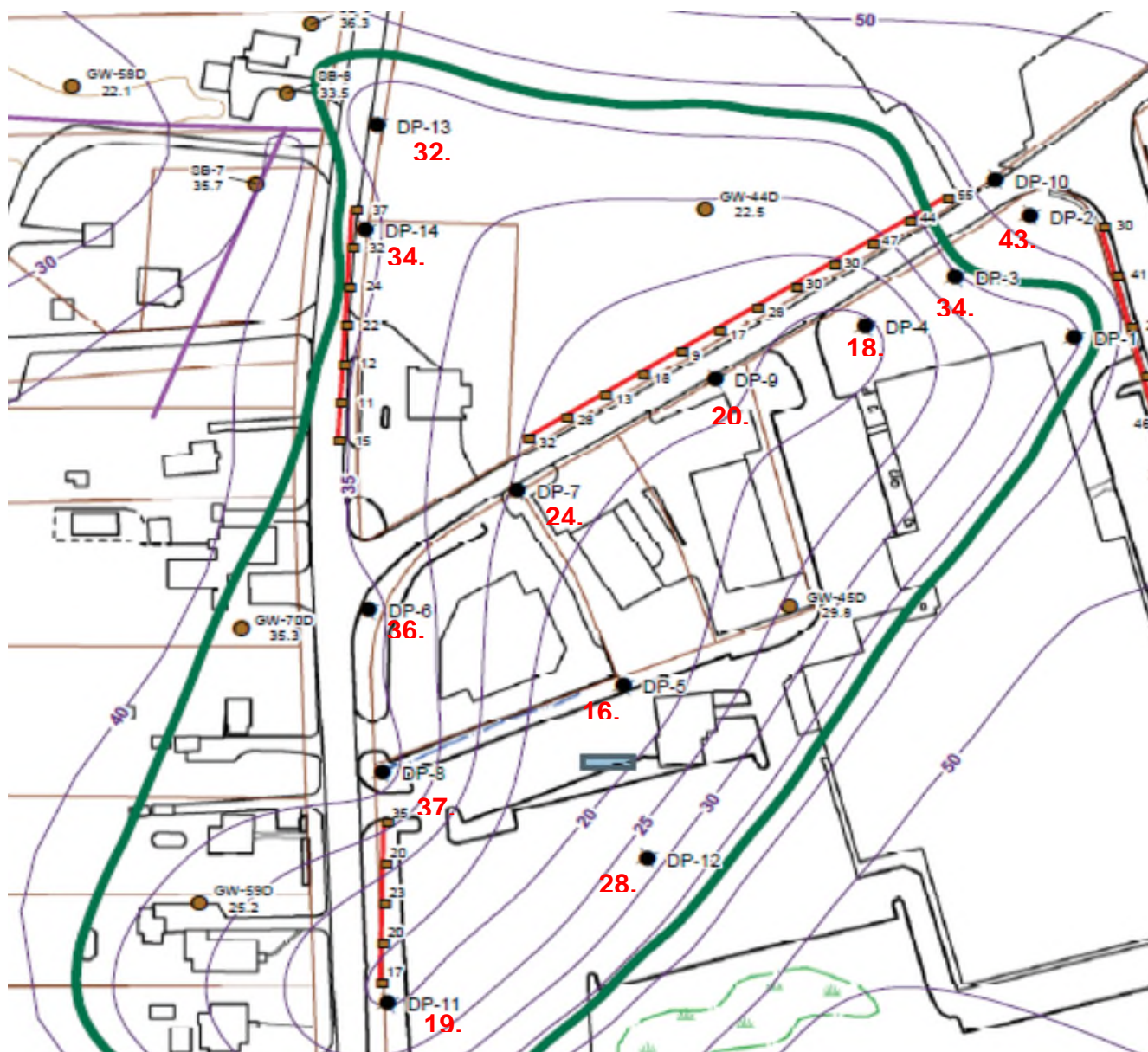
**EPA General Comment #4:** Lateral and vertical resolution on TOR surface: Frank acknowledgement of such resolution issues is needed to assess the *adequacy* and *uniqueness* of the interpretations which have been used historically to define the “Main Street DAPL pool”, “Main Street Saddle”, and other similar features of note at the Site. It is USEPA’s observation that the complexity of the bedrock surface is more variable than these simplistic interpretations allow. For example, upon examining the bedrock surface map created for the Main Street area by Geomega, and later revised by USEPA, the presence of crenulations and variability on the TOR surface over lateral distances of 10’s of feet are seen in nearly all areas where seismic reflection data was collected with a relatively close geophone spacing (~ 30-foot spacing). On the other hand, where data density is low, resolution of second-order features on the TOR surface is limited at best. This suggests lateral variations on bedrock elevation on a similar scale (or finer) than the lateral spacing of the characterization data points should be expected. On the other hand, the technical basis for the “Main Street saddle” is based on three borings spaced on the order of 75 to 100 feet apart, laterally. Clearly such a sparse lateral spacing is not commensurate with the level of variability observed in nature at OCSS or the level of resolution offered by other laterally-integrative methods such as seismic reflection. It must also be acknowledged that there are large swaths of area on the interpretive TOR surface used to define the “Main Street Saddle” and “Main Street DAPL pool” where there is no data of any kind. These issues of lateral resolution and data deficiency also call into question the validity and uniqueness of the interpretations which have been used to define the other DAPL

pools on the Site, such as the Jewel Drive pool, as well the geologic features which are presumed to exist in the intervening areas between the pools. These issues are discussed further in the comments, below.

***Olin Response to USEPA General Comment #4:*** *The seismic data are generally in good agreement with the TOR identified from bore logs (see Comment #8; **Figure B**). However, seismic data, in general, provide a semi-quantitative interpretation and as such the bore logs should be the ultimate harbingers of the bedrock surface.*

*USEPA's CSM (Figure 1b) does not appear to incorporate available relevant data. For example, **Figure A** shows the base of the Main Street DAPL pool using all available data. This figure shows the TOR topography, which clearly indicates the presence of the bedrock saddle.*

*See Figure 1b below...*



**Figure A.** TOR based on borings and the direct push data from Table 2.2-3 of the Draft RI. Note that SB-8 is equivalent to MP-4.

USEPA's statement that there is "no data of any kind" is not accurate (see Response to USEPA General Comment #8 – 2<sup>nd</sup> Paragraph below). While we concur that additional data could aid in refining the location and elevations of the Main Street saddle, we believe this requires careful consideration of strategic data quality objectives.

The accuracy of Olin's DAPL pool topography is further supported by comparing the volume of DAPL pumped with the repeatable DAPL elevation measurements completed during the testing

*of the Off-Property West Ditch DAPL pilot extraction system, which is currently being operated. These volumetric calculations indicate that the current configuration of the OPWD DAPL pool is reasonable and within 5-10% of its current depiction. Data collected during the system operations have been provided to USEPA previously.*

**EPA General Comment #5:** Alternative Conceptualization of DAPL “Pool” areas: Based on the foregoing discussions, it may be more appropriate to conceptualize the major *general* areas of DAPL accumulation as composite *source areas* with many *smaller laterally disconnected depressions* in which DAPL has accumulated rather than large monolithic basins. As such, all depressions on the TOR surface need not be characterized identically as uniform, unfractured, and “tight” (i.e., impervious) which inhibit DAPL penetration to greater depths. As will be discussed in the comments below, data do not support this overly simplified model. Instead, the larger-scale depressions may simply reflect an area - which at finer scales of investigation - reveals many distinct crenulations and depressions of varying dimensions and inconsistent elevations. Fracturing may or may not connect the TOR surface in these crenulations with deeper parts of the bedrock system. The attached Figure 1b., presents such an alternate CSM for areas of DAPL accumulation, similar to the Main Street DAPL area, for comparison with the generalized DAPL pool CSM presented previously by Olin (Figure 1a). Additional comments, below, will address the technical merits for these competing conceptualizations relative to features of interest, starting with the Main Street DAPL pool.

**Olin Response to USEPA General Comment #5:** *Unfortunately, USEPA's TOR cross-section through the Main Street DAPL pool does not appear to be tied to any specific data, so it is difficult to confirm or understand. Further, EPA's cross-section appears to be arbitrary and speculative. Again, Olin refers the USEPA to Figure A which supports the concept of a well-defined Main Street basin. As a practical matter, pumping in the vicinity of DP-5 (at 16.4 ft amsl) would effectively draw down the DAPL surface from its currently estimated 35.5 ft amsl. Although additional wells within this topographic contour should be considered as a means of more effectively extracting DAPL from this pool. Indeed, the Jewel Drive DAPL pool, which has been effectively pumped over a 5-year period shows clear evidence of the efficacy of DAPL drawdown without the need for overly-excessive, unnecessary, and unproductive TOR characterization.*

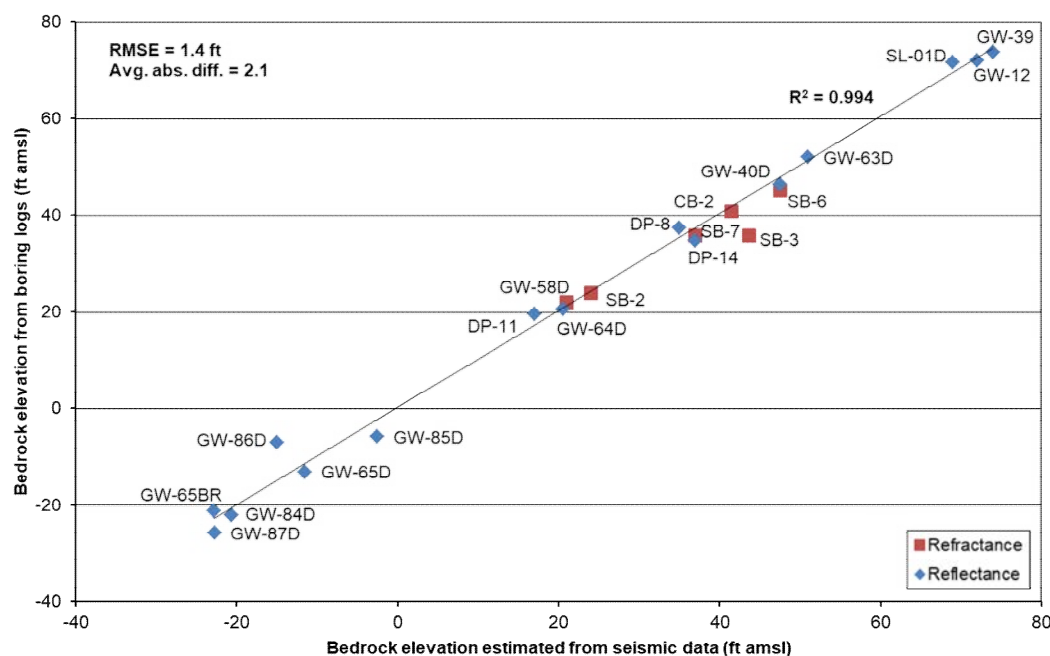
*USEPA has on several occasions raised the idea that removal of all DAPL may be an unrealistic expectation. We agree with this idea. However, we do not agree with USEPA's suggestion above that defining distinct crenulations (i.e., small scale features in the fabric of metamorphic rocks) and depressions of unspecified “varying dimensions” are appropriate objectives. If the objective is to define the bottom of the DAPL pool in which to locate a series of extraction wells, then Olin believes this objective has been achieved, subject to confirmation. The true test of the DAPL pool CSM is through DAPL extraction and demonstrating the progressive decline of the DAPL elevation across the DAPL pool, which Olin has successfully demonstrated over the past 5 years.*

**EPA General Comment #6:** TOR Elevation Uncertainty - Main Street Area: Uncertainties on the data elements used to map TOR surface were discussed in some detail in USEPA’s November 15, 2018 memo, entitled, *Follow-up to Meeting of October 25, 2018: Reevaluation of Technical Basis for “Main Street Saddle” and related CSM elements, initial response*. The following table compiles and summarizes this information:

Data type	Vertical resolution	Comment	Olin Response
direct push boring (geoprobe)	<1-10+	Potential error bar can be large due to potential drill string drift, “false positive” identification of bedrock at shallow “refusal depth”, etc. Error usually biased high, i.e., to (falsely) higher bedrock elevations than actual conditions.	<b>Olin Response:</b> <i>This is incorrect. Drill string drift only accounts for a ~1% deviation (Twining, 2016).</i>
soil boring or MW (no core samples)	<1-5+	Degree of resolution dependent on core recovery and coring methodology. Lack of confirmatory core can result in large errors due to mis-identification of boulders as TOR, false/premature refusal depths, etc. Note that boulders were identified during slurry wall construction and in a number of boring logs around the OCSS, so in this case, boulders are a serious non-hypothetical concern.	<b>Olin Response:</b> <i>Comparing seismic data versus the TOR from adjacent (within ~20 ft) cores demonstrates good agreement (Figure B below).</i>
soil boring or MW (w confirmatory core samples)	<1-5	SB-8 is a “best case” point as confirmatory core samples were collected here. Degree of resolution dependent on coring method, recovery, and ability to resolve transitional material contacts from till to weathered bedrock to competent bedrock. *Assumes 5-ft core sample with negligible recovery.	<b>Olin Response:</b> <i>Confirmation cores have been collected at multiple locations (e.g., SB-1 through SB-9 and JDB-1 through JDB-3)</i>
seismic reflection	<5	Method is generally superior than refraction, but associated error bars are not known, are site-specific and generally better than refraction. A rigorous assessment of site-specific	<b>Olin Response:</b> <i>Comment noted.</i>

		reflection data quality has not been made for this memo.	
seismic refraction	5+	<p>A vertical error of 10% (or greater) of overburden column thickness is typical. However, reporting for the OCSS seismic surveys conducted for the MSDP area suggest even poorer resolution for these surveys due to site-specific factors.</p> <p>- "Results deemed inconclusive by MA DEP" from USEPA Nov. 15 letter: reason for omitting quality of data</p> <p>- SB-7 bedrock is 35.7 ft amsl vs 40 ft contour derived from refraction data: at least ~5' difference in elevation</p> <p>- SB bedrock identification questionable</p>	Olin Response: See Response #6 below.

**Olin Response to USEPA General Comment #6:** While Olin agrees that 10% is a reasonable error bar for seismic refraction from an academic perspective, in practice when locations with confirmatory adjacent bores (within ~20 ft) are compared to the seismic TOR, the agreement is typically within 2-3 ft (**Figure B**). Of more relevance is that the methods appear to align well ( $\pm 2$  ft), providing valuable information on the TOR configuration across the entire OCSS. These data demonstrate that the USEPA's estimate (10+ ft) may be incorrect. Further, the seismic refraction and confirmatory adjacent borings confirm that the collected data complement each other, confirming the fact that the data utilized to develop site CSM are robust.



**Figure B.** TOR based on seismic data compared to boring logs. The average error is  $\pm 2$  ft ( $n=21$ ). Note that there is also a reasonable correlation where direct push bores (e.g., DP-8, -11 and -14) are adjacent to seismic data.

**EPA General Comment #7 (1<sup>st</sup> Paragraph):** Preliminary Assessment of Spatial Resolution of TOR surface at Main Street DAPL pool: Given the TOR uncertainties for the various data types presented in the previous comment, a preliminary assessment of spatial resolution of the TOR surface beneath the Main Street DAPL pool is presented below. To complete this preliminary analysis, the area underlying the mapped outline of the Main Street DAPL pool, as shown on Figure 2.2-9 of the OU3 RI, was divided into two sections, north and south, as shown on the attached Figure 2. The borings, monitoring wells, direct push probe locations, and seismic stations shown on Figure 2.2-9 were totaled and used to prepare the following summary tables. *(omitted here)*

Basic conclusions from this analysis suggest that lateral resolution in the Main Street DAPL pool area - at best - are on the order of:

- One data point per quarter acre (northern portion)
- One data point per half acre (southern portion)

Combining this with the forgoing analysis of vertical resolution yields the following summary table regarding the spatial resolution on the TOR surface in the Main Street DAPL area:

- Lateral resolution: 0.25 to 0.5 acres (or greater)

- Vertical Resolution: < 1-foot (best case) to > 10-feet (worst case)

**Olin Response to USEPA General Comment #7 (1<sup>st</sup> Paragraph):** *The issue is not about number of points per acre, but rather what is required to accurately interpret the system and develop a sufficiently robust CSM, which is a different question. As discussed during the meetings on October 25 and December 10, Olin is not adverse to additional characterization and is willing to collect data that is needed to create a data set sufficient to satisfy the data quality objectives.*

**USEPA General Comment #7 (2<sup>nd</sup> Paragraph):** One must acknowledge that the Main Street DAPL area is a critical element of the Site CSM. One must also conclude that it is under-characterized for the purposes of demonstrating that the system as a whole, acts to control source migration. Additional resolution is needed. Even a cursory examination of this information inevitably leads to a conclusion that the Main Street DAPL area is woefully under-characterized, by just about any standard. Consider that a “typical” small UST site on the order of ¼ acre in size would typically require 3 to 4 monitoring wells, at a minimum. This would suggest an average lateral data density of 3 or 4 times that of the Main Street DAPL area. Even when considering the TOR surface as the only data objective, (which it is not), one would expect a much higher level of resolution on par with other significant source zones in bedrock, e.g., the Quarry and ES/JEBS sites at Loring AFB, Building 81 at NAS South Weymouth, etc. where data density is on the order of 50 to 100 points or more per acre in the high concentration source areas. If a remedy is selected for source control, additional effort will be needed to better understand the level of complexity of the TOR surface at the Main Street DAPL area, as a first order design data objective, to ultimately couple these data with more highly resolved assessments of DAPL occurrence, location, elevation and thickness to formulate a comprehensive and effective source control remedial action. See recommendations, below.

**Olin Response to USEPA Comment #7 (2<sup>nd</sup> Paragraph):** *USEPA has postulated a westward trending valley through the bedrock saddle (e.g., its spillway). However, this interpretation appears to ignore data that contradicts the existence of such a feature. As such, USEPA seems to be weighing data points with low elevations as being more important or reliable than data points showing higher bedrock elevation, which is biasing USEPA’s CSM.*

*A UST site is an irrelevant comparison to the OCSS. Data density is by itself irrelevant. What is relevant is collecting valid and sufficient data to allow remediation to proceed. Olin believes, absent select data gaps, the data collection efforts over the last 20 years have resulted in a robust and correct CSM. As the USEPA points out, there is always room for improvement, with which Olin agrees. We intend to collect additional, appropriate data after continued discussion with, and approval from, the USEPA.*

*The source areas at LAFB which USEPA cites were small source areas. Consequently, a large number of closely spaced borings were necessary to identify and locate each release of perhaps less than 50 gallons of DNAPL. The borings were required to support a TI waiver at each site, pilot testing at one site and a groundwater pumping test at another. In stark contrast, the*

*source area at the Main Street DAPL pool encompasses on the order of 13.5 million gallons of DAPL making it much easier to characterize. Data collected to-date clearly defines the extent of DAPL. Although the “more data is generally is good” argument is common, that argument should be evaluated for its relevance for each site.*

**EPA General Comment #8 (1<sup>st</sup> Paragraph):** Revised interpretation of TOR surface in Main Street DAPL: A revised interpretation of TOR surface in the Main Street DAPL area showing features of interest and data gaps is included on the attached figures. Figure 3 is a map of the TOR surface in the Main Street area. Figure 4 is a cross section West of Main Street (B-B’), and Figure 5 is another north-south cross section aligned east of Main Street. It is interesting to note that the revised figures, which account for the error bars on the TOR data discussed in prior comments, allow room for an interpretation which identifies the Main Street “Saddle” as a smaller feature within a region of relatively higher bedrock elevations.

**Olin Response to USEPA General Comment #8 (1<sup>st</sup> Paragraph):** *Olin questions the accuracy of the error bars portrayed by USEPA appear to be arbitrary and speculative. USEPA has provided no technical foundation or reference back to the scientific literature. With specific reference to Figure B, the average error is  $\pm 2$  ft, which is inconsequential to the overall accuracy of the CSM.*

**USEPA General Comment #8 (2<sup>nd</sup> Paragraph):** This region is designated provisionally as the Main Street “Pinnacle”. As per this interpretation, there also appears to be a small disconnected depression on the bedrock surface in the general area of MP-3, which is designated provisionally as the Main Street “Chalice”, which USEPA interprets as an isolated depression of higher elevation than the average elevation of the Main Street DAPL pool. DAPL presence at this higher elevation may be due to its apparent morphology as a closed depression of smaller scale, possessing an interpreted comparatively “tight bottom” - with a relatively sparse degree of fracturing - that only allows for limited excursion/migration of DAPL, at slow rates.

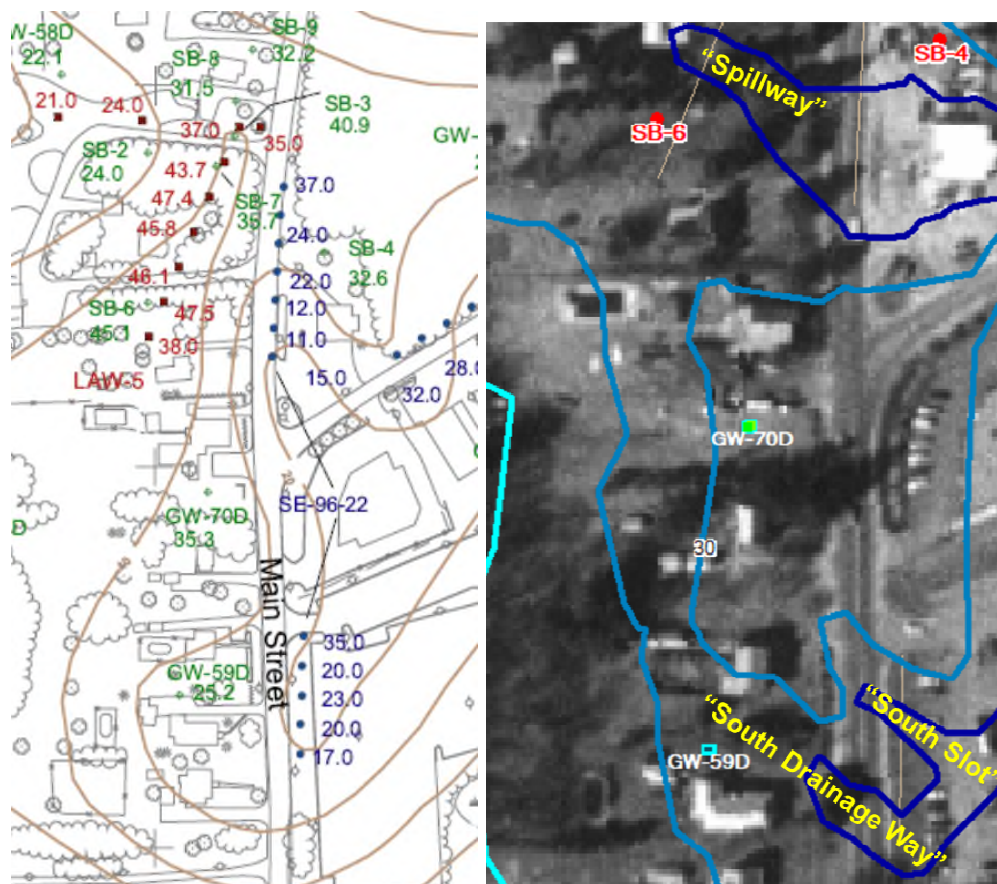
The resolution of this feature is weak given the limited data to the north and east. Additional seismic data proposed in Recommendation 3, below, will help to clarify the presence and dimensions of this feature. In the revised interpretation, the “spillway” feature previously identified by USEPA has been moved slightly to the south to honor the seismic refraction data, but data quality issues have been identified with the refraction data, and a closer examination of that data does *not* support elimination of the “Spillway”. To the south of the “Spillway”, an additional area of relatively higher elevation bedrock, provisionally designated the “Plateau” has been identified. South of the “Plateau”, a smaller scale depression/trough designated as the “Southern Slot” has been identified and is located within a larger-scale depression herein designated as the “South Drainage way” feature. The potential importance of these low-lying valley-like features strongly suggests the need for further resolution in this southern part of the greater Main Street DAPL area.

**Olin Response to USEPA Comment #8 (2<sup>nd</sup> Paragraph):** Olin questions the accuracy of USEPA's CSM for several reasons. Apart from terms such as "chalice", "pinnacle", "spillway", and "plateau," for which there is little if any support, the interpretation fails to consider all of the available data.

USEPA's "pinnacle" appears to be based on boring SB-3; however, closer evaluation of that bore log suggests till/bedrock at an elevation of 35.7 ft amsl rather than the 40.9 ft amsl as posted by USEPA. USEPA's "spillway" is at an elevation of 35.7 ft amsl; however, the 2012 MP-3 DAPL cutoff was at 35.5 ft amsl. Regardless, it is apparent that historically DAPL has migrated through the till (as Olin has represented since 1999) based on the bore log description of "greenish rock," although the seismic reflectance data showed elevations of 43 ft amsl in this area, supporting Olin's contention that geophysics by itself may not provide the desired level of accuracy in this setting. USEPA's "south slot" and "south drainage way" are unsupported by any data.

In fact, the "south drainage way" is directly upgradient of GW-59D (**Figure C**). Although data is sparse, ammonia concentration at that location was 3.7 mg/L in 2004, three orders of magnitude lower than in DAPL. SB-6 was drilled directly adjacent (within 40 ft) to the USEPA's "spillway" location and was sampled from 56 ft bgs, comporting to the till/bedrock interface. The pH of this sample was 6.4, iron 4 mg/L, chloride 230 mg/L and sulfate 337 mg/L (Geomega 1999), clearly inconsistent with a DAPL pathway. The USEPA's CSM fails to include this data.

Referring to USEPA Figure 3, Area A is the most likely pathway for diffuse layer migration (note that downgradient GW-58D has diffuse layer characteristics). On **Figure C**, the low area is in the vicinity of SB-8 (MP-4).



**Figure C.** a) Data defining the TOR in the Main Street area. Note that TOR in SB-3 (Law 1999) has been re-interpreted to be at 36.7 ft amsl, and b) The USEPA's "spillway" and "south drainage way" locations in relation to SB-6 and GW-59D, respectively.

**USEPA General Comment #8 (2<sup>nd</sup> Paragraph):** Further data collection is proposed below (See Recommendations), to allow for improved resolution on the TOR surface in the Main Street DAPL area to confirm the presence, dimensions and elevations of these features as well as to refine the CSM to appropriately inform remedial efforts. Please see associated figures, attached. Again, the presence of these features further supports the need for evaluating source control actions that minimize the migration of both DAPL and highly contaminated groundwater. If a remedy is selected for source control, the recommended data collection efforts will be needed to support the design of effective source control remedial measures.

**Olin Response to USEPA Comment #8 (2<sup>nd</sup> Paragraph):** Olin agrees with carefully-planned data acquisition to support CSM improvement/refinement. We do not believe this will require an exhaustive study and can be accomplished efficiently if the correct data quality objectives (e.g., data for FS or remedial design) are established.

**USEPA General Comment #9:** DAPL measurement Error Bars, Issues, and Uncertainties:

USEPA's assessment concluded that the various approaches used to measure DAPL, although helpful for providing rough estimates of the volume, all have significant issues, error bars, and uncertainties associated with them. As such, they are not accurate enough to provide precise elevation depths and therefore, additional approaches will need to be employed in conjunction with follow-up efforts. As summarized above, these issues include the following:

- Uncertainty regarding estimated DAPL pool elevations and thickness
- Conductivity Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
- Induction Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
- Direct sampling of DAPL from multiport wells - Measurement Accuracy, Precision, and other Issues.

The following table compiles our assessment of the various accuracies, error bars, and other uncertainties associated with the various methods.

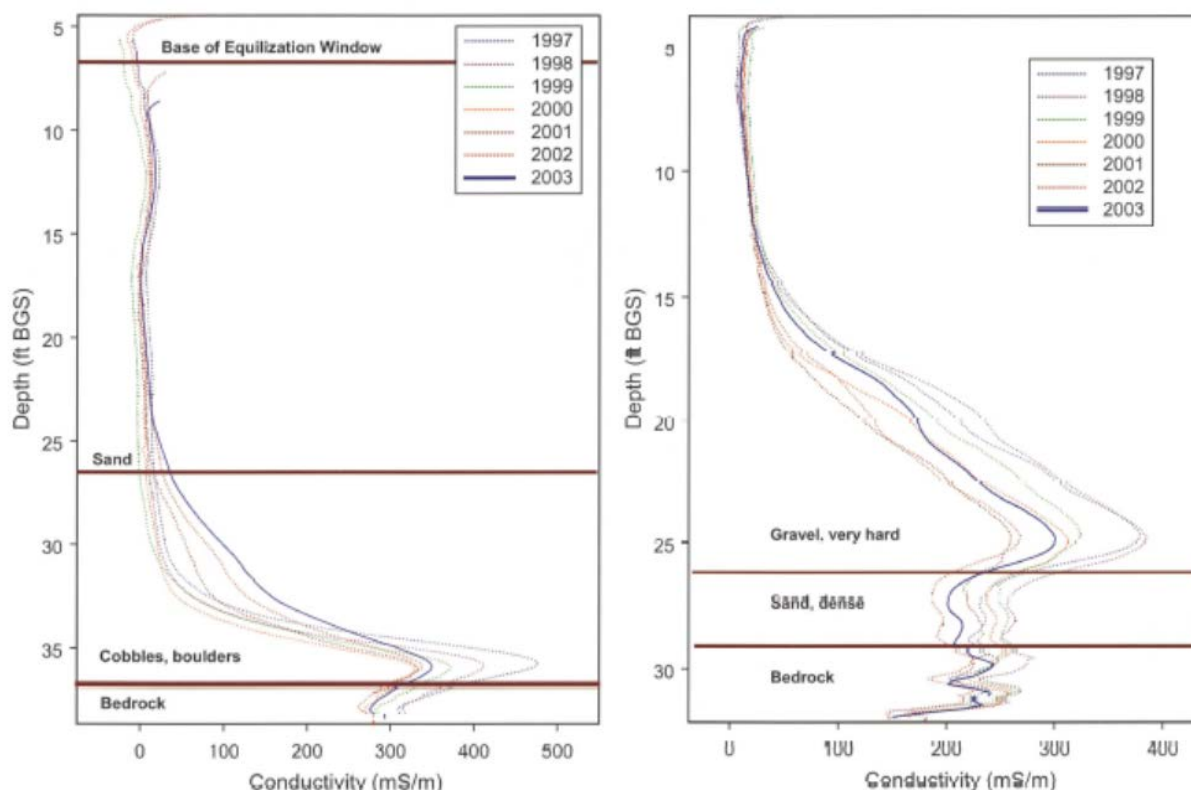
DAPL Estimation method	Vertical resolution (ft)	Error bar (ft)	Comment	Olin Response
Conductivity probe	0.05	1-10+	Magnitude of error bar is correlated with length of screened interval/sand pack in specific monitoring well.	<i>See Figure G</i>
Induction logging	0.1	>>5+	Dependent on specific dimensions of EM logging tool; further analysis is forthcoming. The likely confounding effects of reported solid precipitates (such as chromium sulfates) in the aquifer matrix relative to resolving DAPL elevation with Induction logging have not been quantified for this memo but will likely contribute to a larger error bar.	<i>See Figures D and G</i>
Direct DAPL sampling from multi-	1	1.5-6.5	Distance from screens ranges from 0.5 ft to 4.5 ft away from DAPL surface	

port wells				<b>See Figure E</b>
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Even with an understanding of these limitations, the currently available Site infrastructure and sparse DAPL monitoring network do not allow for unequivocal determination of DAPL position, elevation and thickness. In the Main Street area, only one multi-port well (MP-03) exists and that well is located in the corner of the Main Street DAPL pool and is not sufficient by itself to monitor/cover the larger area. There are also a few nearby monitoring wells. However, these wells have a minimum of 10-foot screen lengths, which also limits the accuracy of any measurements. Therefore, limited data are available to accurately evaluate the height, position and chemistry of this (Main Street) DAPL pool which covers an area several acres in size. More monitoring infrastructure is already in place at the Jewel Drive DAPL pool to support the ongoing DAPL extraction pilot test there. Two multi-port monitoring wells (ML-1 and ML-2) and two induction logging wells consisting of solid PVC filled with distilled water (ILW-1 and ILW-2) are located within 50 feet of the extraction well (EW-1). For well screen details, see Table 1 and Table 2 attached. For well configuration at the Jewel Drive DAPL pool, see attached Figure 2-1 from AMEC, 2014. This information has been used to develop a recommendation, below, to perform a limited scope investigation to clarify current DAPL mass configuration in that area as well as the comparability/accuracy of the various DAPL measurement methods (See Recommendations, below). Once completed, recommendations can then be made for implementing a robust DAPL monitoring program for other DAPL pools at the Site.

***Olin Response to USEPA General Comment #9:*** *Olin disagrees with these error characterizations based on the data as described below as well as in response to USEPA Recommendation #4 (2<sup>nd</sup> Paragraph, Item B) and the affiliated figures.*

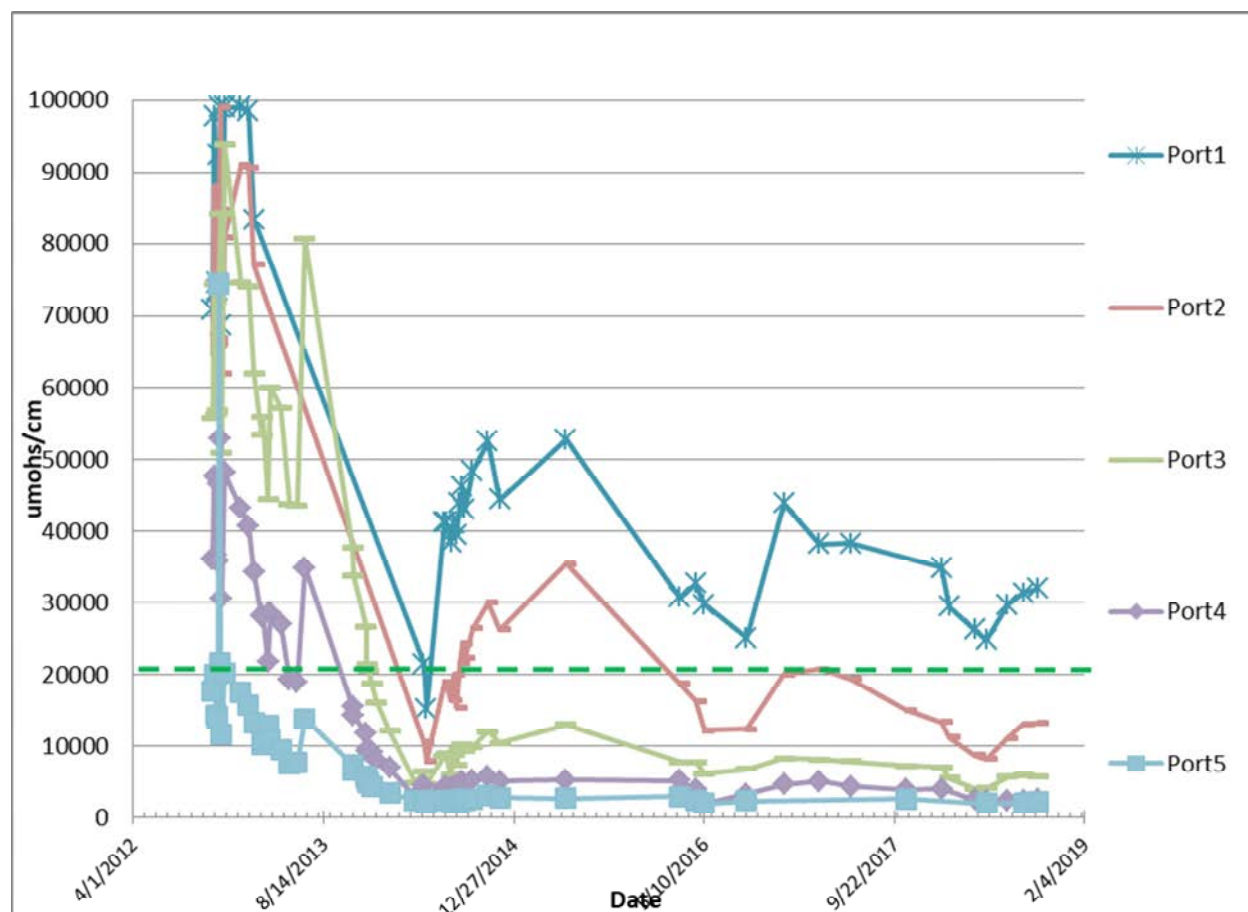
*The elevation of the DAPL pools has been assessed over the years. Inductance logging at multiple wells has shown consistent peaks in elevation rather than fluctuations, as would be the case if there was inherent error in the method. The USEPA claim that there is a greater than 5 ft of error in the top of DAPL elevation is unsupported.*



**Figure D.** Induction logs for, a) GW-35D and b) GW-43D. Note that while the signal strength varied from year to year, the elevation of the peaks remained at a consistent elevation.

Second, the DAPL elevation in the multi-port wells in the Jewel Drive area has responded in a predictable manner to DAPL removal. Based on the DAPL/diffuse layer interface (specific conductivity of 20,600  $\mu\text{mhos/cm}$ ), the DAPL level passed sequentially through port #5 at ~55 ft amsl in 11/2012, #4 at ~54 ft amsl in 11/2013, #3 at ~52 ft amsl in 12/2013 and #2 at ~51 ft amsl by 5/2017 (**Figure E**). All these data have been provided to the USEPA in the past. In addition, the induction log data (**Figure D**) reflect a tight control on elevation.

Third, the specific conductivity profile in MP-2 as of March 2003 compared to the inductance log in adjacent well GW-42D are well correlated, demonstrating that the USEPA's 1-10+ ft error bar affiliated with conductivity probe measurements is also incorrect (**Figure G**; Response #24).



**Figure E.** Specific conductivity in ML1. The green dashed line represents the DAPL/Diffuse Layer cutoff at 20,600  $\mu\text{mhos/cm}$ .

*In summary, Olin has demonstrated through the DAPL extraction and years of related monitoring that the current methods have a high degree of temporal repeatability and accuracy in determining DAPL elevation; with a vertical accuracy within one foot. This is true whether DAPL is in a static condition, under a pumping condition, or during a recovery period following cessation of pumping.*

**USEPA Recommendation #1 (1<sup>st</sup> Paragraph):** It must be acknowledged that Olin's CSM has remained essentially unchanged for over a decade. It must also be acknowledged that this CSM, as any CSM, must be periodically reexamined over time as new thinking, data, and technology come to the fore. Much of USEPA's reexamination is based on more in-depth analysis of *existing* information. During this review, it has become apparent that much of the inertia behind the current CSM derives from a number of factors, such as:

- Over-reliance on older data
- lack of new, updated, or confirmatory data

- Inappropriate or outdated data collection methods
- Equivocal or erroneous interpretation of existing data
- Measurement/assessment of key Site metrics by indirect rather than direct methods,
- Etc.

***Olin Response to USEPA Recommendation #1 (1<sup>st</sup> Paragraph):*** *Olin questions the accuracy of these statements. First, simply because data are old does not make them wrong or useless; second, while there may be slight revisions to the CSM, which is to be expected at any site, the fundamental, underlying data evaluated over the last 20 years is unlikely to result in the sort of wholesale re-evaluation apparently anticipated or suggested by the USEPA. Finally, the USEPA itself appears to have ignored relevant data resulting in their own interpretation and an inaccurate USEPA CSM, e.g., the “spillway” and the “southern slot”.*

**USEPA Recommendation #1 (2<sup>nd</sup> Paragraph):** Any of these issues individually may result in ambiguous or erroneous conclusions, but in combination, the deleterious effects to the CSM may be significant. The overall approach for future data collection at the Site for assessment and remediation purposes needs to be updated/improved as follows:

- Institute regular monitoring of all key parameters and Site metrics in key locations critical to source control and site restoration;  
Update monitoring approaches to employ improved modern, direct-measurement methods;
- Understand accuracy and precision of all monitoring and data collection methods and employ methodologies appropriately in this context;
- Adopt and apply robust QA plans for all relevant activities; and
- Revisit previous conclusions by applying revised/alternative modern methods where appropriate/necessary.

***Olin Response to USEPA Recommendation #1 (2<sup>nd</sup> Paragraph):*** *As recommended by the USEPA, Olin will implement the comprehensive groundwater monitoring program, as outlined in our letter of December 14, 2018. For the 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> bullets, Olin concurs but notes that USEPA has not used contemporary methods of data analysis and interpretation such as regression or computer contouring of data, relying instead on assumptions that are not supported by the data. As mentioned previously, Olin will consider adopting new methodologies/techniques to collect reliable data. However, we cannot discard data just because they were collected using older but widely used techniques with appropriate QA/QC.*

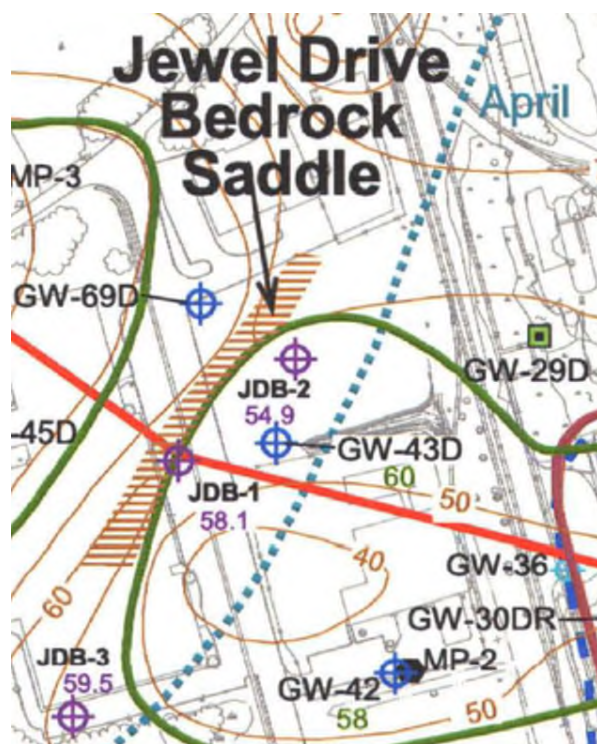
**USEPA Recommendation #2:** Main Street DAPL area: As discussed in GC 8, above, additional data is needed to more accurately resolve the TOR surface in the Main Street DAPL area. Given the quality of the previous seismic reflection data, this method should be augmented to produce a focused “grid” of seismic reflection data which can be used to produce an updated

and improved 3-D map of the TOR surface by employing a methodology which provides a level of vertical resolution of 5 feet or less and lateral resolution of 50 feet or less in all directions. Seismic reflection data should be collected using a relatively fine grid spacing, with a similar or closer geophone spacing as previous seismic reflection surveys (30 feet or less). A 50-foot grid-spacing between lines is proposed for the seismic reflection surveys as a starting point for discussions. However, it may be possible to reduce the density of coverage after discussions with geophysical contractors. A soil boring program, including confirmatory rock cores (e.g., 5 feet or greater), should be employed at least 10 percent of the seismic stations, including at all key locations, to confirm seismic-determined TOR depths. The attached Figure 6 shows the proposed area of supplemental coverage for discussion purposes, which is focused to the western margin of the Main Street DAPL pool, including the previously discussed “Saddle” and “Spillway” features as well as the newly-designated “Chalice”, “Pinnacle”, “Plateau”, “Southern Slot” and “South Drainageway” features.

***Olin Response to USEPA Recommendation #2:*** Olin agrees that there are some key locations that will better refine the configuration of the Main Street saddle area. However, apart from disagreeing with USEPA's CSM, Olin also disagrees that a seismic campaign will provide the necessary level of detail. There are a myriad of bore locations in the OCSS that can drive careful location of confirmatory (or otherwise) data to refine the CSM. Olin recognizes that this will be a sequential exercise to support remedial decisions; however, the additional investigations must be to support remedial decisions rather than “it would be nice to know,” or “bedrock wells are required.” Olin is willing to work with the USEPA to develop an appropriate and functional work plan that will help refine the site CSM. However, collecting additional data to verify every data point that was collected over 20 years is unlikely to have any meaningful impact on the feasibility studies.

**USEPA Recommendation #3 (1<sup>st</sup> Paragraph):** Jewel Drive Top-of-Bedrock Surface: In the interest of improving DAPL extraction effectiveness, it is also critical to perform additional efforts to produce a more highly resolved map of the TOR elevation relative to the following efforts in the Jewel Drive area: a) to provide a technically defensible foundation to a more robust, holistic analysis of extraction efforts to date; b) to support follow-up DAPL measurement assessments proposed in the recommendation, below, and c) ultimately to support design/installation of additional extraction wells or modification of existing wells as driven by the data. Experts from USEPA's Office of Research and Development (ORD) have begun an in-depth review of work-to-date towards the goal of developing strategies for optimized extraction of DAPL related to the Jewel Drive pilot test.

***Olin Response to USEPA Recommendation #3 (1<sup>st</sup> Paragraph):*** It is unclear whether USEPA reviewed or are familiar with the data and results of the Jewel Drive bedrock saddle investigation that was conducted April 2003 (Geomega 2003). Three rotosonic bores were advanced to bedrock. The TOR was determined to be at 58.1 ft amsl in JDB-1, 54.8 ft amsl in JDB-2 and 59.5 ft amsl in JDB-3 (**Figure F**) which both confirmed and refined the Jewel Street saddle TOR. In addition, data collected from MP-2 corroborate April 2003 data.



**Figure F.** Locations and revised bedrock TOR contours in the Jewel Drive area (Geomega 2003; Figure 1).

As mentioned during the meeting on December 10, Olin is interested in considering and evaluating other options with EPA ORD, and/or collecting additional data, if warranted, as soon as possible to determine, and develop viable remedial alternatives to address DAPL.

**USEPA Recommendation #3 (2<sup>nd</sup> Paragraph):** Current recommendations suggest short screened-intervals for extraction points, of as little as 1-ft in the vertical dimension may be more effective in allowing for sustained extraction. In this context, the need for a more highly resolved map of the TOR surface at Jewel drive becomes a high priority design data objective. A similar approach to that requested for the Main Street Area, above, is a starting point for discussions, but a higher level of resolution may be needed in the Jewel Drive area to support remedial design, including more precise placement of extraction well screened-intervals relative to TOR and DAPL elevations. A review of existing TOR data across the Site suggests that a methodology and implementation strategy which provides a level of vertical resolution of 2-feet or less and lateral resolution of 10 feet or less in all directions may be needed to achieve design objectives. Seismic reflection data should therefore be collected using a relatively fine grid spacing and tight geophone spacing. A 10-ft X 10-ft grid-spacing is proposed for the seismic reflection surveys as a starting point for discussions. The area to be surveyed at the specified higher resolution should minimally be a 200-ft X 200-ft box centered on EW-1. However, given

the relatively high data density in the Jewel drive area, it may be possible to reduce the density of seismic reflection coverage after discussions with geophysical contractors. A precursor to these discussions will require an in-depth assessment of data quality ('error bar', accuracy, and precision) inherent to the current data set used to produce the best currently-available TOR elevation map in the Jewel Drive area. A soil boring program, including confirmatory rock cores, should be employed at least 10 percent of the seismic stations, including at all key locations, to confirm seismic-determined TOR depths. Please see also GC 9, above.

**Olin Response to USEPA Recommendation #3 (2<sup>nd</sup> Paragraph):** *It is unclear why additional information is needed for the Jewel Drive DAPL pool as it has been depleted by ~4 ft between 2013 and 2017 (Figure E). Further, approximately, 30% of the pool has been removed and the removal is proceeding in general accordance with the approved design. However, as mentioned above, Olin will consider and evaluate other options in conjunction with EPA ORD to develop viable remedial alternatives for DAPL. Also refer to Figure F characterizing the Jewel Drive bedrock saddle.*

*We note that the original DAPL pilot design recommended two foot screens as early as 2003/2004 but MassDEP and USEPA objected due to concern that this would place the extraction well screen largely in the till. USEPA at that time advocated a fully penetrating screen that spanned the entire DAPL column to the diffuse interface. The current five foot screen length was a compromise by Olin.*

*As discussed above, further characterization is unnecessary at this time (Figure F). Olin is committed to source removal and/or reduction, but in a measured way which is practically feasible. Olin is willing to work with the EPA to develop a functional work plan that will help refine the site CSM as appropriate as well as to develop viable and practicable remedial alternatives.*

*The purpose/objective of data density proposed by USEPA of a 10X10 reflection grid within a 200 X 200 box centered around EW-1 is unclear. We are not trying to evaluate the extent of impacts, but rather are trying to evaluate alternatives for remedial action that has been ongoing for over 5 years. Olin has provided data collected prior to and from the ongoing remedial activity.*

**USEPA Recommendation #4 (1<sup>st</sup> Paragraph):** Improved Methodologies needed for DAPL Measurement: Induction logging and multi-port sampling (for all DAPL-specific indicator parameters) should be combined with a field profiling program that includes electrical conductivity logging, such as a membrane interface probe or equivalent, collection of co-located groundwater profiling samples at approximately the same elevation as nearby multi-port wells and from equivalent depths at selected locations between these elevations, and collection of co-located soil samples.

**Olin Response to USEPA Recommendation #4 (1<sup>st</sup> Paragraph):** Olin concurs that a down-well specific conductivity profile is appropriate and will provide pertinent and useful information (see **Figure G** showing the excellent agreement between the specific conductivity in MP-2 versus the conductance profile in adjacent GW-42D).

**USEPA Recommendation #4 (2<sup>nd</sup> Paragraph, Item A-D):** Specifically, we note that the DAPL pool at Jewel Drive is instrumented with two induction logging wells (ILW-1 and ILW-2) and three multi-port monitoring wells (ML-1, ML-2, and MP-2) in addition to traditional screened monitoring wells (GW-42S and GW-42D). These should be included in an evaluation of DAPL and soil characteristics to develop a more complete understanding of the electrical conductivity of the soil and to provide more resolution than is available with the current multi-port wells. Therefore, an additional direct-push technology (DPT) drilling program should be considered that would include the following:

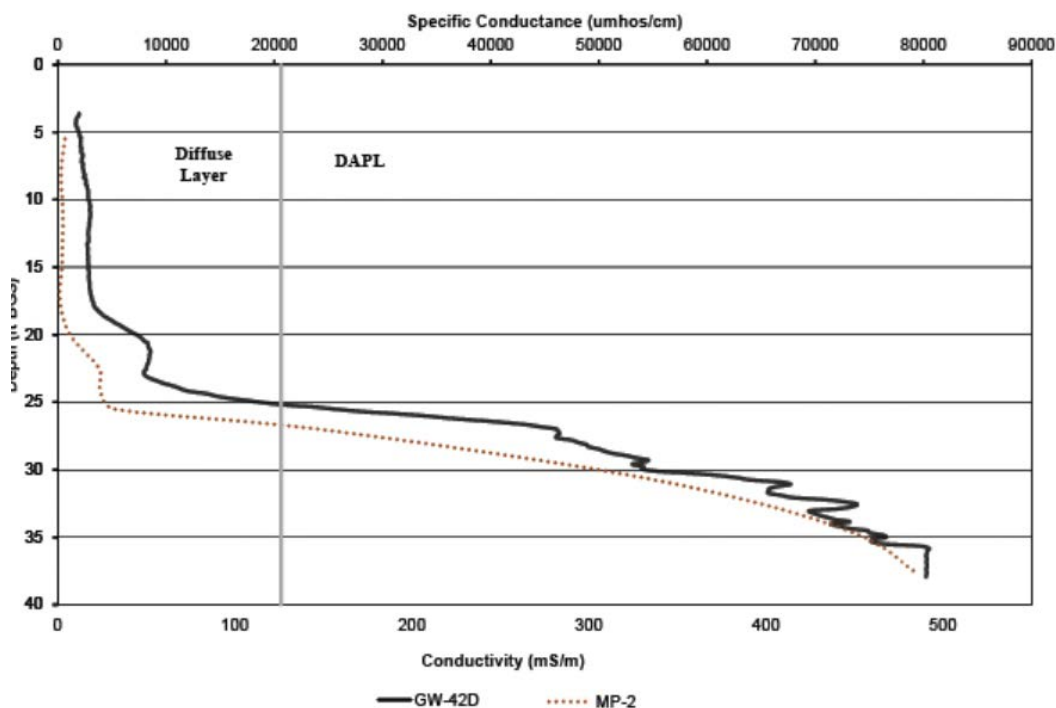
**Item A:** Creation of a more highly resolved map of the TOR surface in the Jewel Drive area, particularly the area within a 200-ft radius from EW-1, is a necessary first step to evaluating DAPL elevation and thickness in a more technically defensible manner; see previous recommendation, above.

**Olin Response to USEPA Recommendation #4 (2<sup>nd</sup> Paragraph, Item A):** Olin disagrees with this proposal because DAPL removal is proceeding as anticipated, and the estimated volumes are within 5-10% of that calculated based on the current TOR topography.

**Item B:** Soil sampling to evaluate concentrations of DAPL contaminants and the presence of precipitates that may cause false positives for induction logging. A method which can provide continuous soil profiles through depth intervals of interest is needed.

**Olin Response to USEPA Recommendation #4 (2<sup>nd</sup> Paragraph, Item B):** The induction log in GW-42D from 2003 is in good agreement with the specific conductivity profile in adjacent MP-2 (within ~20 ft) collected at the same time. There is no evidence of bias due to precipitates (**Figure G**).

See Figure G below...



**Figure G.** The specific conductivity trend in MP-2 ports is consistent with the conductance in adjacent well GW-42D.

**Item C:** Groundwater profiling using a technique capable of relatively fine vertical resolution (such as a Waterloo® profiler) to evaluate groundwater concentrations at the same elevation as the multi-port wells and at discrete depth intervals between those elevations. A 2-ft vertical discretization interval (or less) between samples is recommended, at least in critical areas and depth intervals.

**Olin Response to USEPA Recommendation (2<sup>nd</sup> Paragraph, Item C):** Olin believes that the current resolution (1-1.5 feet) is adequate to meet data quality objectives given the availability of data and the excellent delineation of the top of DAPL from multiple lines of evidence (see **Figures D, E and G**). Olin is willing to work with the EPA to consider and utilize methods to collect data to refine the CSM.

**Item D and 3<sup>rd</sup> Paragraph:** Electrical conductivity logging to compare soil and groundwater profiling results to the induction logging well results.

The DPT drilling should be performed in the immediate vicinity of the multi-port and induction logging wells, and then at set distances away (recommend 50 feet, 100 feet, and 200 feet) to determine the horizontal variability in these measurements. Comparison of these different data sets at Jewel drive will help to determine DAPL and soil characteristics in and above the other DAPL pools.

***Olin Response to USEPA Recommendation #4 (2<sup>nd</sup> Paragraph, Item D and 3<sup>rd</sup> Paragraph):*** *Olin is willing to consider data collection techniques to refine the CSM but unclear whether such proposed investigation would advance either the FS or aid in developing source control alternatives.*

**USEPA Recommendation #4 (4<sup>th</sup> Paragraph):** After the more data-rich Jewel Drive DAPL pool is more highly resolved and improved methodologies are implemented for time-series measurement of DAPL elevation and thickness in key locations, a similar reassessment of the DAPL pool(S) in the Main Street Area, with the benefit of the updated TOR mapping included in recommendation 2, above, will be needed.

***Olin Response to USEPA Recommendation #4 (4<sup>th</sup> Paragraph):*** *Olin disagrees with this conclusion. Olin is willing to consider data collection techniques to refine the CSM, but is unclear whether such proposed investigation would advance either the FS, or aid in developing interim action alternatives.*

*Finally, as requested by EPA in its letter dated November 15, 2018, an exhaustive search found some limited raw BIPs data from the MP-4 installation in 2000 (included along with this transmittal).*

## **References**

Geomega. 1999. Olin Wilmington Technical Series VI. The Main Street Boring program: Confirmation of the Bedrock saddle. Geomega, Boulder, Colorado.

Geomega. 2003. Olin Wilmington Technical Series XXVIII. Results of the 2003 (7<sup>th</sup> Annual) Induction-Logging and Multilevel Piezometer Sampling Event. Geomega, Boulder, Colorado.

LAW. 1999. Revised Top of Bedrock Report. Olin Corporation Facility, Wilmington, Massachusetts. Law Engineering, Kennesaw, Georgia.

Twining, B. V. (2016). *Borehole deviation and correction factor data for selected wells in the eastern Snake River Plain aquifer at and near the Idaho National Laboratory, Idaho* (No. 2016-5163). US Geological Survey. <https://pubs.usgs.gov/sir/2016/5163/sir20165163.pdf>

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS		GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter		Units	Result	Qualifier	Result	Qualifier
NDMA	T	N-Nitrosodi-n-butylamine		mg/L				
NDMA	T	N-Nitrosodi-n-propylamine		mg/L			0.000019	U
NDMA	T	N-Nitrosodimethylamine		mg/L			0.024	J
NDMA	T	N-Nitrosomethylethylamine		mg/L				
Inorganics_Wet Chem	T	Alkalinity, Total		mg/L				
Inorganics_Wet Chem	T	Ammonia		mg/L				
Inorganics_Wet Chem	T	Bicarbonate Alkalinity, as CaCO3		mg/L				
Inorganics_Wet Chem	T	Bromide		mg/L	0.64		0.53	
Inorganics_Wet Chem	T	Carbonate Alkalinity, as CaCO3		mg/L				
Inorganics_Wet Chem	T	Chemical Oxygen Demand		mg/L				
Inorganics_Wet Chem	T	Chloride		mg/L	350		1600	
Inorganics_Wet Chem	T	Fluoride		mg/L				
Inorganics_Wet Chem	T	Nitrate as N		mg/L	17		0.078	
Inorganics_Wet Chem	T	Nitrite as N		mg/L	0.1	U	0.01	U
Inorganics_Wet Chem	T	Nitrogen, as Ammonia		mg/L	83		470	
Inorganics_Wet Chem	T	Nitrogen, Total Kjeldahl		mg/L				
Inorganics_Wet Chem	T	Orthophosphate		mg/L				
Inorganics_Wet Chem	T	Phosphate, Total as P		mg/L				
Inorganics_Wet Chem	T	Sulfate		mg/L	790		6300	
Inorganics_Wet Chem	T	Temperature		Deg C				
Inorganics_Wet Chem	T	Total Alkalinity, as CaCO3		mg/L				
Inorganics_Wet Chem	T	Total Dissolved Solids		mg/L				
Inorganics_Wet Chem	T	Total Organic Carbon		mg/L				
Inorganics_Wet Chem	T	Total Suspended Solids		mg/L				
Inorganics_Wet Chem	T	pH		PH Units				
Inorganics_Wet Chem	D	Iron, Ferric		mg/L				
Inorganics_Wet Chem	D	Total Dissolved Solids		mg/L				
VOCs	T	1,1,1-Trichloroethane		mg/L	0.001	U	0.001	U
VOCs	T	1,1,2-Trichloro-1,2,2-Trifluoroethane		mg/L	0.001	U	0.001	U
VOCs	T	1,1-Dichloroethane		mg/L	0.001	U	0.00057	J
VOCs	T	1,1-Dichloroethene		mg/L	0.001	U	0.00085	J
VOCs	T	1,2,4-Trichlorobenzene		mg/L	0.001	U	0.002	
VOCs	T	1,2,4-Trimethylbenzene		mg/L	0.001	U	0.00026	J
VOCs	T	1,2-Dichlorobenzene		mg/L	0.001	U	0.00049	J
VOCs	T	1,2-Dichloroethane		mg/L	0.001	U	0.011	

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS		GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units		Result	Qualifier	Result	Qualifier
VOCs	T	1,3,5-Trimethylbenzene	mg/L		0.001	U	0.001	U
VOCs	T	1,3-Dichlorobenzene	mg/L		0.001	U	0.001	U
VOCs	T	1,4-Dichlorobenzene	mg/L		0.001	U	0.00058	J
VOCs	T	1,4-Dioxane	mg/L			R		R
VOCs	T	2,4,4-Trimethyl-1-pentene	mg/L		0.001	U	0.0013	
VOCs	T	2,4,4-Trimethyl-2-pentene	mg/L		0.001	U	0.001	U
VOCs	T	2-Chlorotoluene	mg/L		0.001	U	0.001	U
VOCs	T	4-Chlorotoluene	mg/L		0.001	U	0.001	U
VOCs	T	Acetone	mg/L		0.05	UJ	0.05	UJ
VOCs	T	Benzene	mg/L		0.001	U	0.0057	
VOCs	T	Bromobenzene	mg/L		0.001	U	0.001	U
VOCs	T	Bromochloromethane	mg/L		0.001	U	0.001	U
VOCs	T	Bromodichloromethane	mg/L		0.001	U	0.00024	J
VOCs	T	Bromoform	mg/L		0.001	U	0.00099	J
VOCs	T	Butane, 2-methoxy-2-methyl-	mg/L		0.002	J	0.005	U
VOCs	T	Carbon disulfide	mg/L		0.01	U	0.01	U
VOCs	T	Carbon tetrachloride	mg/L		0.001	U	0.003	J
VOCs	T	Chlorobenzene	mg/L		0.001	U	0.00058	J
VOCs	T	Chloroethane	mg/L		0.002	U	0.002	U
VOCs	T	Chloroform	mg/L		0.00022	J	0.0083	
VOCs	T	Chloromethane	mg/L		0.002	U	0.00077	UJ
VOCs	T	Cis-1,2-Dichloroethene	mg/L		0.00067	J	0.051	
VOCs	T	Cyclohexane	mg/L		0.01	U	0.01	U
VOCs	T	Dibromochloromethane	mg/L		0.0005	U	0.0035	
VOCs	T	Dibromomethane	mg/L		0.001	U	0.00033	J
VOCs	T	Diethyl ether	mg/L		0.01	U	0.01	U
VOCs	T	Ethylbenzene	mg/L		0.001	U	0.00045	J
VOCs	T	Isopropyl ether	mg/L		0.01	U	0.01	U
VOCs	T	Isopropylbenzene	mg/L		0.001	U	0.001	U
VOCs	T	Methyl cyclohexane	mg/L		0.01	U	0.0024	J
VOCs	T	Methyl Tertbutyl Ether	mg/L		0.033		0.0091	
VOCs	T	Methylene chloride	mg/L		0.002	U	0.0019	J
VOCs	T	n-Butylbenzene	mg/L		0.001	U	0.0008	J
VOCs	T	Naphthalene	mg/L		0.005	U	0.005	U
VOCs	T	Propylbenzene	mg/L		0.001	U	0.001	U

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS		GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units		Result	Qualifier	Result	Qualifier
VOCs	T	sec-Butylbenzene	mg/L		0.001	U	0.001	U
VOCs	T	Styrene	mg/L		0.001	U	0.001	U
VOCs	T	Tetrachloroethene	mg/L		0.001	U	0.0031	
VOCs	T	Tetrahydrofuran	mg/L		0.01	U	0.01	U
VOCs	T	Toluene	mg/L		0.001	U	0.0051	
VOCs	T	trans-1,2-Dichloroethene	mg/L		0.001	U	0.00087	J
VOCs	T	Trichloroethene	mg/L		0.0071		0.27	
VOCs	T	Trichlorofluoromethane	mg/L		0.001	U	0.001	U
VOCs	T	Vinyl chloride	mg/L		0.0005	U	0.0061	
VOCs	T	Xylene, o	mg/L		0.001	U	0.001	U
VOCs	T	Xylenes (m&p)	mg/L		0.002	U	0.002	U
SVOCs	T	1,2,4-Trichlorobenzene	mg/L					
SVOCs	T	1,2-Dichlorobenzene	mg/L					
SVOCs	T	1,3-Dichlorobenzene	mg/L					
SVOCs	T	1,4-Dichlorobenzene	mg/L					
SVOCs	T	1,4-Dioxane	mg/L					
SVOCs	T	1-Methylnaphthalene	mg/L		0.0045	U	0.0045	U
SVOCs	T	2,4,6-Trichlorophenol	mg/L		0.0045	U	0.00048	J
SVOCs	T	2,4-Dichlorophenol	mg/L		0.0045	U	0.0011	J
SVOCs	T	2,4-Dimethylphenol	mg/L		0.0045	U	0.0045	U
SVOCs	T	2,6-Dinitrotoluene	mg/L		0.0045	U	0.0045	U
SVOCs	T	2-Methylnaphthalene	mg/L		0.00091	U	0.00091	U
SVOCs	T	2-Methylphenol	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	2-Nitrophenol	mg/L		0.0045	U	0.0045	U
SVOCs	T	3 & 4 Methylphenol	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	4,6-Dinitro-2-methylphenol	mg/L		0.0045	U	0.0045	U
SVOCs	T	4-Bromophenyl phenyl ether	mg/L		0.0045	U	0.0045	U
SVOCs	T	4-Chlorophenyl phenyl ether	mg/L		0.0045	U	0.0045	U
SVOCs	T	4-Nitroaniline	mg/L		0.0045	U	0.0045	U
SVOCs	T	4-Nitrophenol	mg/L		0.0045	UJ	0.0012	J
SVOCs	T	Acenaphthene	mg/L		0.00091	U	0.00091	U
SVOCs	T	Acenaphthylene	mg/L		0.00027	U	0.00027	U
SVOCs	T	Acetophenone	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	Aniline	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	Anthracene	mg/L		0.00091	U	0.00091	U

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS		GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units		Result	Qualifier	Result	Qualifier
SVOCs	T	Azobenzene	mg/L		0.0045	U	0.0045	U
SVOCs	T	Benzaldehyde	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	Benzo(a)anthracene	mg/L		0.00027	U	0.00027	U
SVOCs	T	Benzo(a)pyrene	mg/L		0.00018	UJ	0.00018	U
SVOCs	T	Benzo(b)fluoranthene	mg/L		0.00027	UJ	0.00027	U
SVOCs	T	Benzo(ghi)perylene	mg/L		0.00045	UJ	0.00045	U
SVOCs	T	Benzo(k)fluoranthene	mg/L		0.00027	UJ	0.00027	U
SVOCs	T	Benzoic Acid	mg/L			R	0.0045	U
SVOCs	T	Biphenyl	mg/L		0.0045	U	0.00095	J
SVOCs	T	Bis(2-Ethylhexyl)phthalate	mg/L		0.0018	U	0.0077	UJ
SVOCs	T	Butylbenzylphthalate	mg/L		0.0045	U	0.0045	U
SVOCs	T	Caprolactam	mg/L			R	0.0045	UJ
SVOCs	T	Carbazole	mg/L		0.0045	U	0.0045	U
SVOCs	T	Chrysene	mg/L		0.00091	U	0.00091	U
SVOCs	T	Di-n-butylphthalate	mg/L		0.0045	U	0.0045	U
SVOCs	T	Di-n-octylphthalate	mg/L		0.0045	UJ	0.0045	U
SVOCs	T	Dibenz(a,h)anthracene	mg/L		0.00045	UJ	0.00045	U
SVOCs	T	Diethylphthalate	mg/L		0.0045	U	0.0045	U
SVOCs	T	Dimethylformamide	mg/L					
SVOCs	T	Dimethylphthalate	mg/L		0.0045	U	0.0045	U
SVOCs	T	Diphenyl ether	mg/L		0.0045	U	0.011	
SVOCs	T	Diphenylamine	mg/L					
SVOCs	T	Diphenylmethanone	mg/L		0.0045	U	0.0045	U
SVOCs	T	Fluoranthene	mg/L		0.00091	U	0.00091	U
SVOCs	T	Fluorene	mg/L		0.00091	U	0.00091	U
SVOCs	T	Indeno(1,2,3-cd)pyrene	mg/L		0.00045	UJ	0.00045	U
SVOCs	T	N-Nitrosodi-n-propylamine	mg/L		0.0045	UJ		
SVOCs	T	N-Nitrosodimethylamine	mg/L		0.0045	UJ		
SVOCs	T	N-Nitrosodiphenylamine	mg/L		0.0045	U	0.0045	U
SVOCs	T	Naphthalene	mg/L					
SVOCs	T	Phenanthrene	mg/L		0.00018	U	0.00018	U
SVOCs	T	Phenol	mg/L		0.0045	UJ	0.0045	UJ
SVOCs	T	Pyrene	mg/L		0.0045	U	0.0045	U
VPH	T	Benzene	mg/L					
VPH	T	C5-C8 Aliphatics	mg/L					

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS	GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units	Result	Qualifier	Result	Qualifier
VPH	T	C5-C8 Aliphatics (unadj.)	mg/L				
VPH	T	C9-C10 Aromatics	mg/L				
VPH	T	C9-C10 Aromatics (unadj.)	mg/L				
VPH	T	C9-C12 Aliphatics	mg/L				
VPH	T	C9-C12 Aliphatics (unadj.)	mg/L				
VPH	T	Ethylbenzene	mg/L				
VPH	T	Methyl Tertbutyl Ether	mg/L				
VPH	T	Naphthalene	mg/L				
VPH	T	Toluene	mg/L				
VPH	T	Volatile Petroleum Hydrocarbons, Total	mg/L				
VPH	T	Xylene, o	mg/L				
VPH	T	Xylenes (m&p)	mg/L				
EPH	T	2-Methylnaphthalene	mg/L				
EPH	T	Acenaphthene	mg/L				
EPH	T	Acenaphthylene	mg/L				
EPH	T	Anthracene	mg/L				
EPH	T	Benzo(a)anthracene	mg/L				
EPH	T	Benzo(a)pyrene	mg/L				
EPH	T	Benzo(b)fluoranthene	mg/L				
EPH	T	Benzo(ghi)perylene	mg/L				
EPH	T	Benzo(k)fluoranthene	mg/L				
EPH	T	C11-C22 Aromatics (unadj.)	mg/L				
EPH	T	C11-C22 Aromatics Adjusted	mg/L				
EPH	T	C19-C36 Aliphatics	mg/L				
EPH	T	Chrysene	mg/L				
EPH	T	Dibenz(a,h)anthracene	mg/L				
EPH	T	Extractable Petroleum Hydrocarbons, Total	mg/L				
EPH	T	Fluoranthene	mg/L				
EPH	T	Fluorene	mg/L				
EPH	T	Indeno(1,2,3-cd)pyrene	mg/L				
EPH	T	Naphthalene	mg/L				
EPH	T	Phenanthrene	mg/L				
EPH	T	Pyrene	mg/L				
Metals	T	Aluminum	mg/L	0.38		0.22 J	
Metals	T	Antimony	mg/L	0.006 U		0.03 U	

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS	GW GW-58D 10/21/2010 OC-GW-58D-XXX FS		
Method Class	Fraction	Parameter		Units	Result	Qualifier	Result	Qualifier
Metals	T	Arsenic		mg/L	0.01	UJ	0.1	U
Metals	T	Barium		mg/L	0.022		0.011	J
Metals	T	Beryllium		mg/L	0.001	U	0.005	U
Metals	T	Boron		mg/L				
Metals	T	Cadmium		mg/L	0.0041	J	0.005	UJ
Metals	T	Calcium		mg/L	81		410	
Metals	T	Chromium		mg/L	0.0062	U	0.012	J
Metals	T	Chromium, Hexavalent		mg/L				
Metals	T	Cobalt		mg/L	0.049		0.47	
Metals	T	Copper		mg/L	0.017		0.05	U
Metals	T	Iron		mg/L	1.6		140	
Metals	T	Lead		mg/L	0.0026	J	0.025	UJ
Metals	T	Magnesium		mg/L	23		130	
Metals	T	Manganese		mg/L	4.4	J	32	
Metals	T	Mercury		mg/L	0.0002	U	0.0002	U
Metals	T	Molybdenum		mg/L				
Metals	T	Nickel		mg/L	0.043	J	0.34	
Metals	T	Potassium		mg/L	9.3		31	
Metals	T	Selenium		mg/L	0.004	J	0.05	U
Metals	T	Silver		mg/L	0.005	U	0.025	U
Metals	T	Sodium		mg/L	250		1300	
Metals	T	Strontium		mg/L				
Metals	T	Thallium		mg/L	0.001	U	0.00027	J
Metals	T	Tin		mg/L	0.05	UJ	0.25	U
Metals	T	Vanadium		mg/L	0.0021	J	0.05	UJ
Metals	T	Zinc		mg/L	2		0.23	J
Metals	D	Aluminum		mg/L				
Metals	D	Antimony		mg/L				
Metals	D	Arsenic		mg/L				
Metals	D	Barium		mg/L				
Metals	D	Beryllium		mg/L				
Metals	D	Boron		mg/L				
Metals	D	Cadmium		mg/L				
Metals	D	Calcium		mg/L				
Metals	D	Chromium		mg/L				

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS	GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units	Result	Qualifier	Result	Qualifier
Metals	D	Chromium, Hexavalent	mg/L				
Metals	D	Cobalt	mg/L				
Metals	D	Copper	mg/L				
Metals	D	Iron	mg/L				
Metals	D	Lead	mg/L				
Metals	D	Lithium	mg/L				
Metals	D	Magnesium	mg/L				
Metals	D	Manganese	mg/L				
Metals	D	Mercury	mg/L				
Metals	D	Molybdenum	mg/L				
Metals	D	Nickel	mg/L				
Metals	D	Potassium	mg/L				
Metals	D	Selenium	mg/L				
Metals	D	Silver	mg/L				
Metals	D	Sodium	mg/L				
Metals	D	Strontium	mg/L				
Metals	D	Thallium	mg/L				
Metals	D	Tin	mg/L				
Metals	D	Vanadium	mg/L				
Metals	D	Zinc	mg/L				
Non Standard Analysis	T	4,4'-Isopropylidenediphenol	mg/L				
Non Standard Analysis	T	4-(1,1,3,3-Tetramethylbutyl)phenol	mg/L				
Non Standard Analysis	T	4-Nonylphenol (Tech.)	mg/L				
Non Standard Analysis	T	Kempore (Azodicarbonamide)	mg/L				
Non Standard Analysis	T	Monomethylhydrazine (MMH)	mg/L				
Non Standard Analysis	T	OPEX	mg/L				
Non Standard Analysis	T	Perchlorate	mg/L				
Non Standard Analysis	T	Phthalic Acid/Phthalic anhydride	mg/L				
Non Standard Analysis	T	UDMH	mg/L				
Hydrazine/aldehydes	T	Benzaldehyde	mg/L				
Hydrazine/aldehydes	T	Formaldehyde	mg/L				
Hydrazine/aldehydes	T	Hydrazine	mg/L				
Hydrazine/aldehydes	T	Monomethylhydrazine (MMH)	mg/L				
Hydrazine/aldehydes	T	UDMH	mg/L				
Pest./PCBs/Herb.	T	2,4,5-T	mg/L				

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS	GW GW-58D 10/21/2010 OC-GW-58D-XXX FS		
Method Class	Fraction	Parameter		Units	Result	Qualifier	Result	Qualifier
Pest./PCBs/Herb.	T	2,4,5-TP/Silvex		mg/L				
Pest./PCBs/Herb.	T	2,4-D		mg/L				
Pest./PCBs/Herb.	T	4,4'-DDD		mg/L				
Pest./PCBs/Herb.	T	4,4'-DDE		mg/L				
Pest./PCBs/Herb.	T	4,4'-DDT		mg/L				
Pest./PCBs/Herb.	T	Aldrin		mg/L				
Pest./PCBs/Herb.	T	Alpha-BHC		mg/L				
Pest./PCBs/Herb.	T	Beta-BHC		mg/L				
Pest./PCBs/Herb.	T	Chlordane (technical)		mg/L				
Pest./PCBs/Herb.	T	Dalapon		mg/L				
Pest./PCBs/Herb.	T	Dieldrin		mg/L				
Pest./PCBs/Herb.	T	Dinoseb		mg/L				
Pest./PCBs/Herb.	T	Endosulfan II		mg/L				
Pest./PCBs/Herb.	T	Endrin		mg/L				
Pest./PCBs/Herb.	T	Endrin aldehyde		mg/L				
Pest./PCBs/Herb.	T	Gamma-BHC/Lindane		mg/L				
Pest./PCBs/Herb.	T	Heptachlor		mg/L				
Pest./PCBs/Herb.	T	Picloram		mg/L				
DMF	T	Dimethylformamide		mg/L				
Oils and Fuels	T	PETROLEUM NAPHTHA		mg/L				
Oils and Fuels	T	Unmatched		mg/L				
Uranium	T	Uranium		mg/L				
RAD	T	Alpha Activity		pCi/L				
RAD	T	Beta Activity		pCi/L				
RAD	T	Radium-226		pCi/L				
RAD	T	Radium-228		pCi/L				
RAD	T	Radon		pCi/L				
Acids	T	Phthalic acid		mg/L				
Color	T	Color, Apparent		Color Unit				
Ferrous Iron	D	Iron, Ferrous		mg/L				
Freezing Point	T	Freezing Point		Deg C				
Odor	T	Odor		TON				
ORP	T	Oxidation Reduction Potential		mv				
Specific Conductance	T	LAB SPECIFIC CONDUCTANCE		mS/cm				
Specific Conductance	T	Specific Conductivity		mS/cm				

**Attachment A**  
**Groundwater Results for GW-58D**  
**Olin Chemical Superfund Site**  
**Wilmington, MA**

				Media Location Sample Date Sample ID Qc Code	GW GW-58D 5/24/2010 OC-GW-58D-XXX FS	GW GW-58D 10/21/2010 OC-GW-58D-XXX FS	
Method Class	Fraction	Parameter	Units	Result	Qualifier	Result	Qualifier
Specific Gravity	T	Specific Gravity	g/mL				
Turbidity	T	Turbidity	NTU				

**Archived:** Tuesday, March 05, 2019 11:05:31 AM

**From:** Carbutt, Carole

**Sent:** Friday, December 21, 2018 5:30:06 PM

**To:** Pat Field; Jennings, Lynne; Funderburg, Lisa AHOUS; Cianciarulo, Robert; Zucker, Audrey; Olson, Bryan; Kilborn, John; Pechulis, Kevin; DiLorenzo, James; Smith, Christopher; Brandon, William; Jennifer Lambert; Elizabeth Cooper; Elissa Tonkin

**Cc:** Thompson, Peter H.; Esakkiperumal, Chinny CERG; Cashwell, James M CERG; Murphy, Michael J

**Subject:** Response to Comments Letter from Olin Corporation

**Sensitivity:** Normal

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<https://www.dropbox.com/sh/g1i5q3dej5luiuok/AACKSqlwC3PY8Ydz2-IOzuTGa?dl=0>

Thank you,

**Carole Carbutt**

Administrative Assistant

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[carole.carbutt@woodplc.com](mailto:carole.carbutt@woodplc.com)

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